National Aeronautics and Space Administration

Overview of International Space Station Electrical Power System

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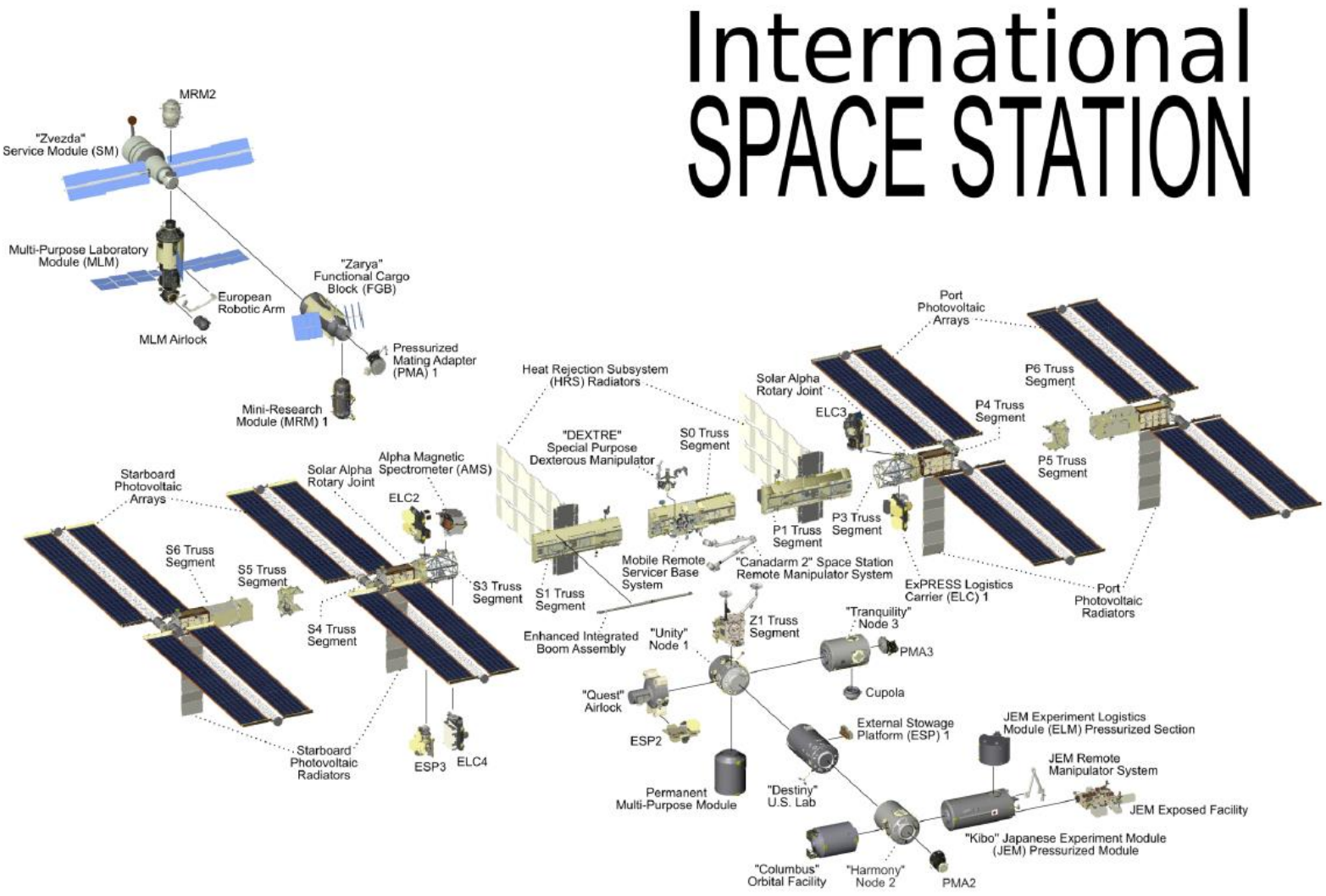
ISS Overview

The International Space Station (ISS) is a unique scientific platform that enables researchers from all over the world to put their talents to work on innovative experiments that could not be done anywhere else.

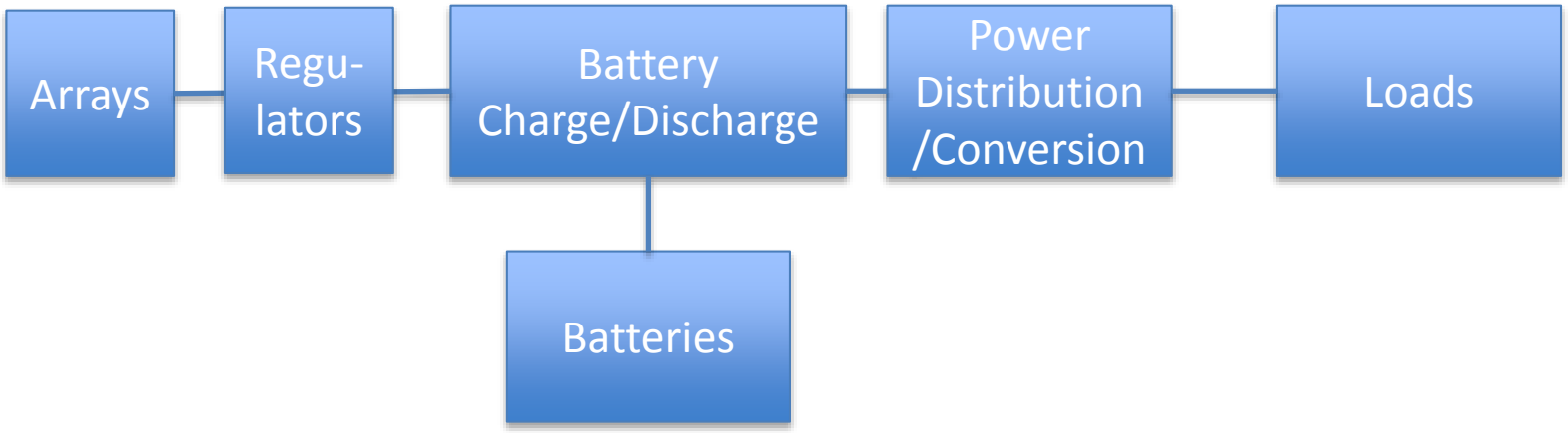
Orbit:

- Inclination: 51 degrees
- Period: 90 minutes
- Altitude: ~ 240 miles

ISS Overview



ISS Electrical Power System Block Diagram

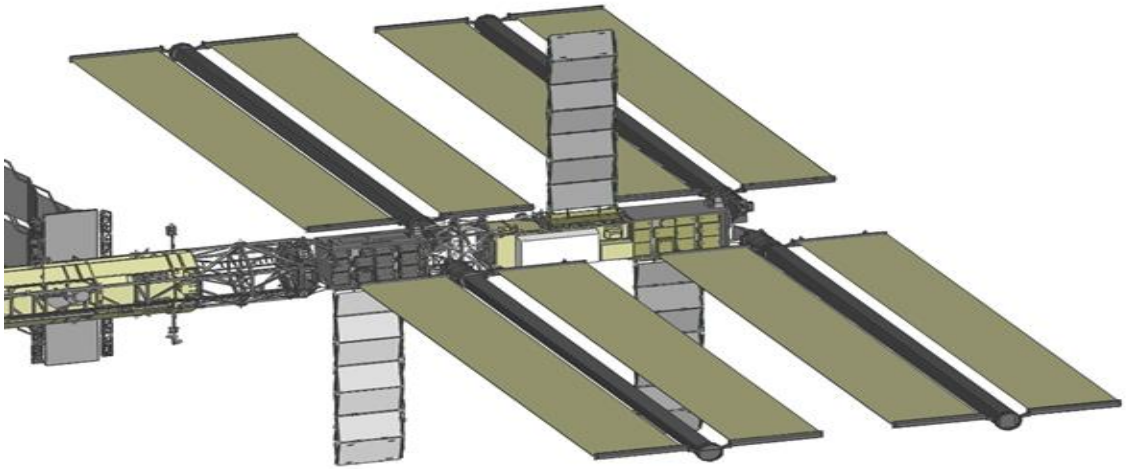


- Divided into 8 separate power channels (busses)
- Arrays: Intermittent power (90 minute orbit, 30 minute eclipse)
- Batteries: Supply power during eclipse periods
- Power Distribution: handles faults

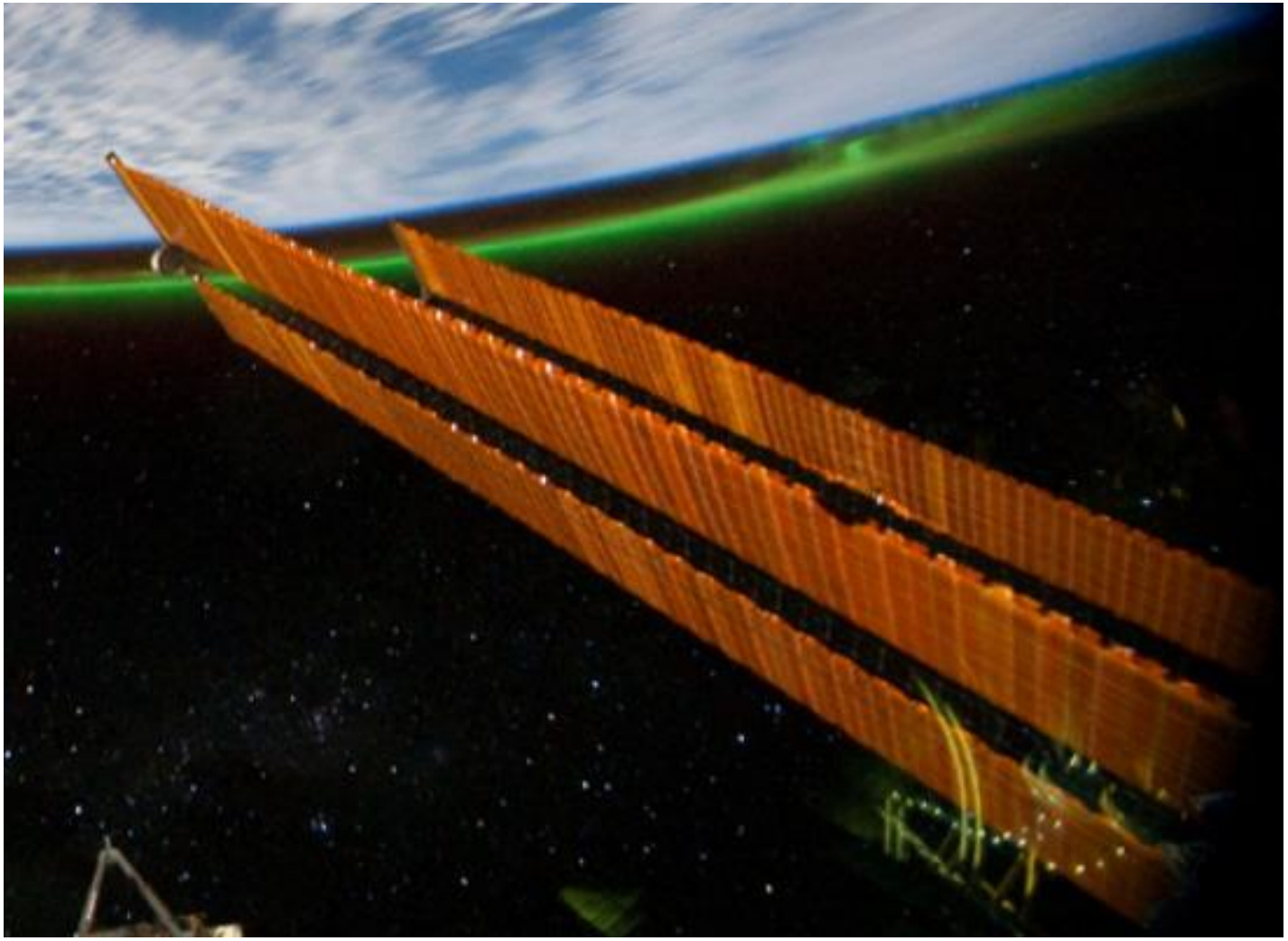
ISS Solar Arrays: Overview

Solar Array Wing (SAW):

- There are 32,800 solar cells total on the ISS Solar Array Wing, assembled into 164 solar panels.
- **Largest ever** space array to convert solar energy into electrical power
- 8 Solar Array Wings on space station (2 per PV module)
- Nominal electrical power output ~ 31 kW per Solar Array Wing at beginning of life, 8 SAW total for **~248 kW total power**
- 4 PV modules (PVMs) on ISS, 2 power channels per module for **8 power channels total**



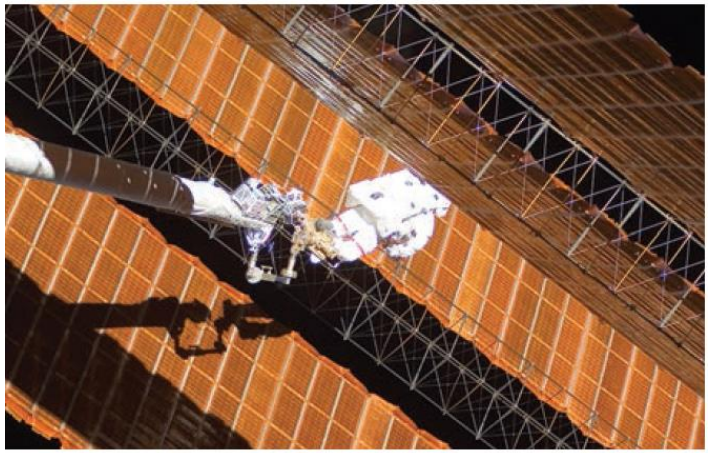
ISS Solar Array Wing



ISS Solar Arrays: Operational factors

Operational factors for solar arrays:

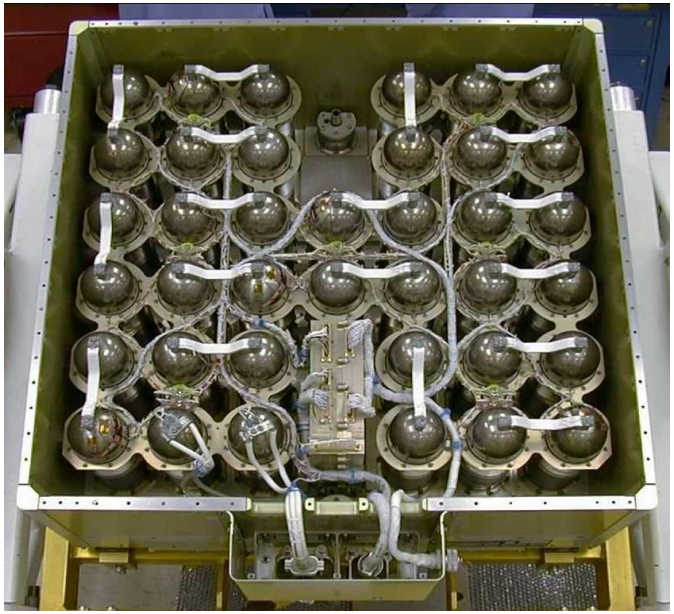
- Feather for EVAs (space walks)
  - Shadows cold, sunshine hot.
- Visiting vehicles: Maneuvering rockets can hit arrays with plumes
  - Force on arrays
  - Array degradation
- Reboost
  - Forces on arrays
- Structural thermal
  - Longeron shadowing



NASA astronaut Scott Parazynski, anchored to the Articulating Portable Foot Restraint (APFR) on the Orbiter Boom Sensor System (OBSS), assesses repair work on the P6 4B Solar Array Wing (SAW) as the array is deployed during an extravehicular activity (EVA).

ISS Batteries

- Consists of 38 lightweight Nickel Hydrogen cells and associated electrical and mechanical equipment, packaged in an ORU enclosure.
- During insolation, solar electric energy, regulated by the charger (BCDU), will replenish energy stores in preparation for the next eclipse cycle
- Two ORU makes a battery. There are 24 batteries on ISS at AC.
- Present batteries are reaching the end of their lifecycles, and replacement Lithium Ion batteries are being developed.



Power Distribution: Operational Factors

Power distribution system operational factors:

- Load shedding:
  - Several load shed tables
  - Often needed to cope with array feathering
- Equipment failures
- EVA (spacewalk) safety
- Reconfiguration:
  - Large structural reconfigurations
  - Changes to experimental racks.
- Power balancing
  - Loads can be shifted from one bus to another to a limited degree
- Helping with troubleshooting of other systems (spikes on current waveforms)

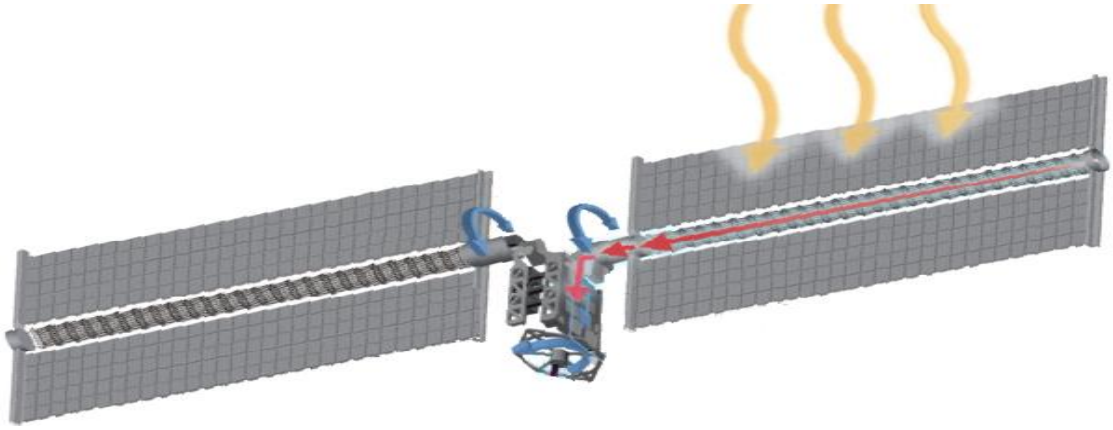
Autonomous power functions

Autonomous power functions on the ISS:

- Fault isolation (circuit breaker action)
  - Single equipment failure will not take down bus
- Battery charge and discharge
  - Optimized to reduce battery cycle life degradation
- Array orientation
  - Pointing algorithm tracks sun over orbit

Utility Outlet Panel

Battery Charge/Discharge Unit



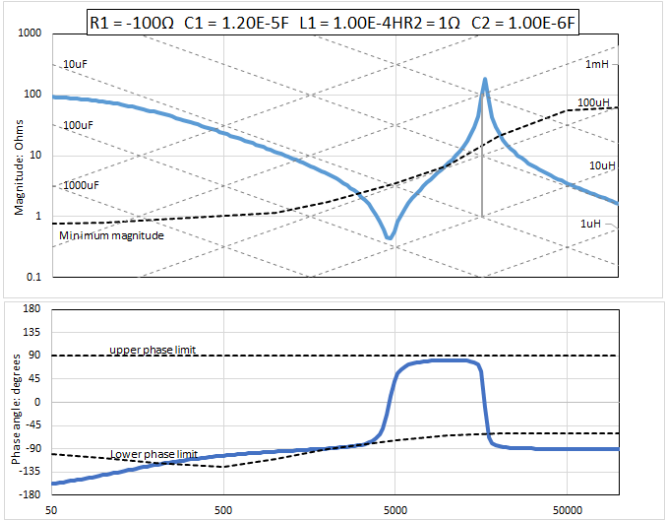
ISS Electrical System Challenges

- Aging equipment
  - Extension of certification
  - Battery wear-out
  - Solar array wear-out
- Increasing amount of loads
  - Power generation capability is decreasing
- Limited crew time for on-orbit operations and maintenance
  - Extensive planning needed for activities
- Limited data rate for telemetry:
  - Most currents are 1 Hz sample rate
  - Fastest current sample rate is 50 Hz
- Test lab on the ground, but not full scale mockup

ISS Electrical System Integration Testing

ISS assembly sequence connected large complex modules that had not been connected on the ground.

- No complete ground mockup/Iron-bird
- Extensive ground performance testing and modelling required
  - EMI: conducted emissions and susceptibility (bus ripple)
  - Load and Source Impedance for stability
  - Bus transients



ISS: comparison to terrestrial microgrid

	ISS Power System	Hypothetical Microgrid
Voltage type	DC	AC
Configuration changes while operating	YES	YES
Intermittent power sources	YES	YES
Centralized Control	YES	NO
Battery Storage	YES	YES